UCRL-2644

UNCLASSIFIED

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

Contract No. 7405-eng-48

PROTON-PROTON SCATTERING EXPERIMENTS AT 170 AND 260 MEV

Owen Chamberlain and John D. Garrison

July 1, 1954

Berkeley, California

PROTON-PROTON SCATTERING EXPERIMENTS AT 170 AND 260 MEV*

Owen Chamberlain and John D. Garrison+

Radiation Laboratory, Department of Physics
University of California, Berkeley, California

July 1, 1954

The differential proton-proton scattering cross section has been measured at 170 and 260 Mev for laboratory scattering angles of 4.4 to 30 degrees using the University of California synchrocyclotron. This experiment is an extension to smaller scattering angles of work completed earlier at this laboratory,[1] and is essentially in agreement with this earlier work. The angular region of the differential p-p scattering cross section presented here is of interest because it is in this region that the experimental results are at greatest variance with the theory.[2]

The 340-Mev full-energy proton beam from the cyclotron was reduced in energy by using beryllium absorbers. Following the absorbers the proton beam was collimated and analyzed in a magnet to provide a beam reasonably parallel and homogeneous in energy. A liquid hydrogen target was used.[3] The target presented 5.6 inches of liquid hydrogen to the beam for scattering.

The scattered protons were counted using a telescope consisting of two liquid scintillation counters in coincidence. The first counter served to define the solid angle subtended by the telescope at the target. The second counter was placed to the rear of the first and was larger, so that multiple-scattering losses would be small.

The background coincidence counts, consisting primarily of protons scattered from the collimator system and hydrogen target walls, were determined by using a dummy target to simulate the empty hydrogen target. It was found that the dummy

---

* This work was performed under the auspices of the U.S. Atomic Energy Commission.

+ Now at Sloane Physics Laboratory, Yale University, New Haven, Conn.

1. O. Chamberlain, E. Segre, and C. Wiegand, Phys. Rev. 83, 923 (1951)

2 Reference one contains a number of references on this subject.

3 The target has been described by J. W. Mather and E. A. Martinelli, Phys. Rev. 92, 785 (1953)

target gave a false measure of the true counting background because the stopping power of the full liquid hydrogen exceeded that of the dummy target by the stopping power of the liquid hydrogen. Some of the low-energy protons contributing to the counter background coincidences had insufficient range to count when the hydrogen target was in the proton beam, but were able to count when the dummy was in the beam. This effect was appreciable at scattering angles close to the proton beam, and was corrected by placing absorber with just the stopping power of the liquid hydrogen between the two scintillation counters when counts were taken with the dummy target in the proton beam.

The beam was monitored by an ionization chamber, which was calibrated by a Faraday cup.[4] The Faraday cup calibration was done with varying amounts of absorber placed before it, permitting a determination of the energy distribution and mean range of the proton beam. The nuclear loss corrections in the absorber were determined using the absorption cross sections of Kirschbaum.[5]

The measured differential cross sections are shown in Fig. 1. The differential cross section was found to be the same at both energies, within the accuracy of the experiment. The cross sections presented here are much lower than those of some previous workers;[6-8] however, they are in agreement with more recent work.[9, 10] Fig. 1 includes curves drawn for Coulomb scattering plus a constant nuclear cross section. Deviations from the curves should represent interference between Coulomb and nuclear scattering.

The errors indicated in the figure are those determined by combining the known errors affecting the shape of the angular distribution. The errors in the total cross sections are estimated to be about eight percent.

A complete acoount of the experiment will be published later.

---

[4] The reference in footnote one describes the ion chamber and Faraday cup.

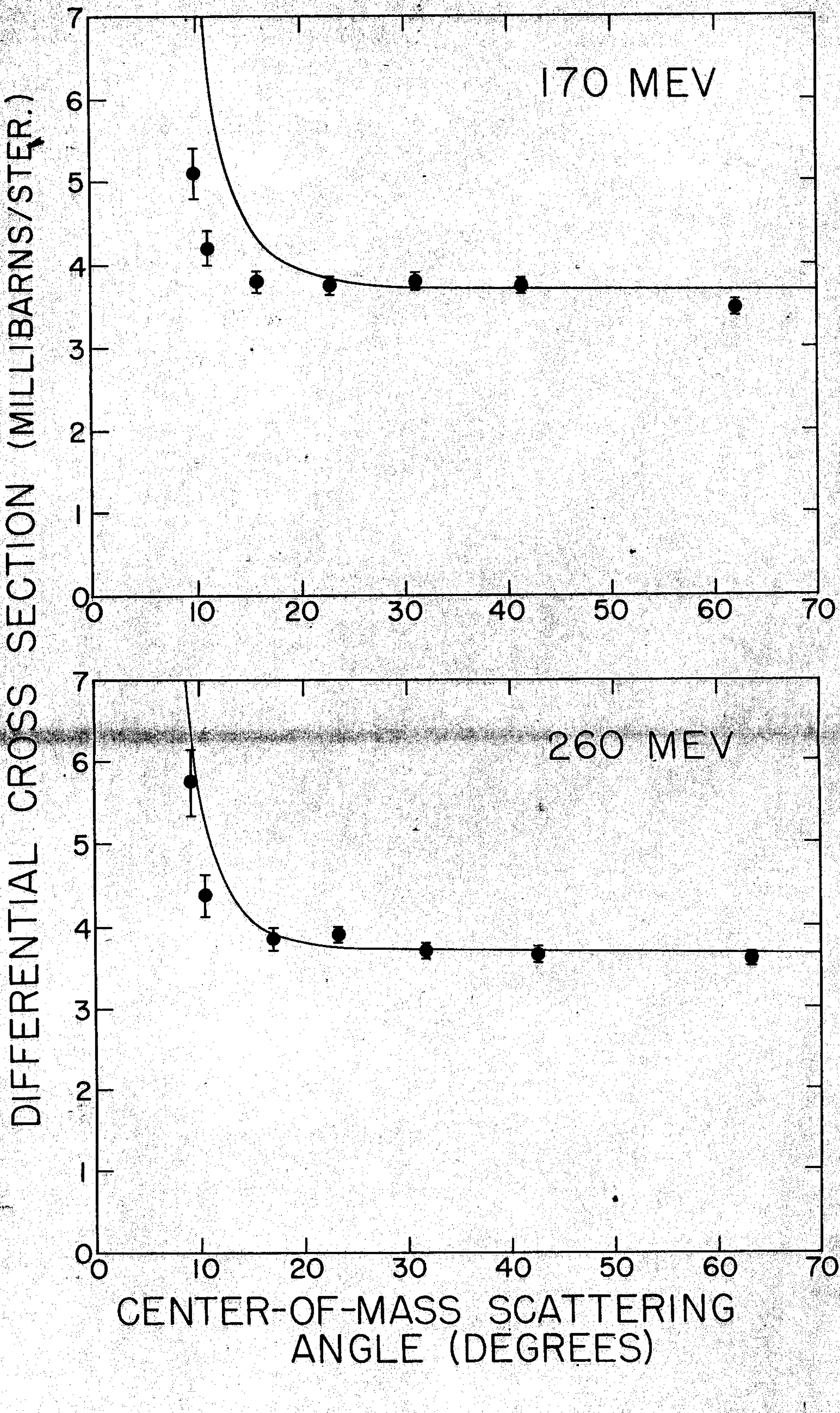
[5] A. J. Kirschbaum, Nuclear Absorption Cross Sections for High Energy Protons, University of California Radiation Laboratory Report No. UCRL-1967, October, 1952.

[6-8] C. L. Oxley and R. D. Schamberger, Phys. Rev. 85, 416 (1952).
O. A. Towler, Phys. Rev. 84, 1262 (1951).
Cassels, Pickavance, and Stafford, Proc. Roy. Soc (London) 214, 262 (1952).

[9, 10] J. Marshall, L. Marshall, and V. A. Nedzel, Phys. Rev. 92, 834 (1953).
Chamberlain, Pettengill, Segrè, and Wiegand, Phys. Rev. 93, 1424 (1954); also some unpublished results, Gordon H. Pettengill, private communication.

Figure Caption

Fig. 1. Center-of-mass differential p-p scattering cross sections *versus* center-of-mass scattering angle. The points represent the experimental results, with errors as they apply to the angular distribution. The solid lines show the sum of a constant nuclear cross section and pure Coulomb scattering cross section. Energies are given for the laboratory system.



170 MEV
260 MEV
DIFFERENTIAL CROSS SECTION (MILLIBARNS/STER.)
CENTER-OF-MASS SCATTERING ANGLE (DEGREES)
0
1
2
3
4
5
6
7
0
10
20
30
40
50
60
70